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Marine Machinery Association Spring Conference

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April 26, 2011

- **Key to the continued success of the Navy being able to deliver *maintenance free mission days*, will be the development and implementation of a robust Condition Based Maintenance capability that integrates:**

- equipment/system failure risk assessment (what needs to be done)
- maintenance advance planning and scheduling (when the work will need to be done)
- maintenance best practices (how the work will be done)

CBM + MFOP

What is Condition Based Maintenance?



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- **CBM is a process of scheduling prescribed maintenance tasks, through the analysis of *equipment condition indicating data and operational utilization (stress) data***
 - Current equipment condition and the forecasted risk of failure (future reliability) are estimated using the acquired information, in conjunction with the planned equipment operating (duty cycle) profiles
 - Business rules related to unacceptable equipment risks are invoked to allow:
 - Accurate advance planning and scheduling of maintenance and logistic support activities
 - Maintenance to be accomplished on-board or ashore to support high mission availability
 - Optimized logistic footprint

Why Navy Needs CBM?



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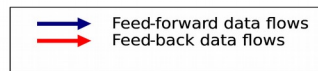
- Failure Prevention During Mission Periods
 - Continuous equipment condition and system risk visibility
 - Early detection of machinery condition and predicted risk change
 - Failure Risk prediction accounting for planned operating tempo
- Advance Planning & Scheduling of Pre-Planned Work to be Performed During In-Port Periods
 - Define what (specific work action) needs to be done with at least an 80% confidence factor
 - Define when (which availability or period of convenience) the work needs to be done
 - Define why (equipment risk to mission) the scope needs to be done
- Reduction of Shipboard Operators and Maintainers
 - Failure prevention and reaction during mission periods
- OPNAV Newly Defined Sustainment Outcome Metrics
 - Material Reliability
 - Material Availability
 - Mean Down Time
 - TOC

- LCS CBM+ technology is an integration of Navy program of record and COTS technology in order to:
 - Continuously acquire machinery operating and event data
 - Continuously assess the current condition of critical equipment
 - Estimate the probability of future failure risk, when operated within a planned operating profile
 - Provide the machinery current condition, predicted failure risk probability, to the LCS Reliability Engineer for maintenance decision management support
 - Receive conditions found and work accomplished information related to the recommended maintenance action to validate risk models
 - Compute Sustainment Process Metrics relative to the selected critical ship-board systems

LCS CBM+ Process



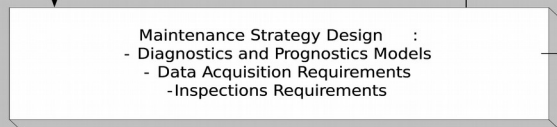
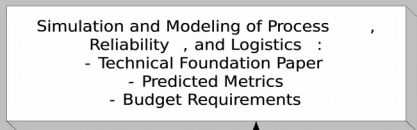
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One Time Design Process



Business VALUE &
Sustainment METRICS

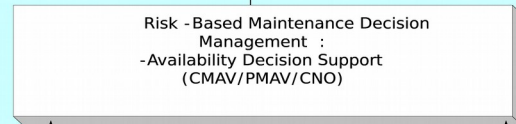


Continuous Sustainment Process



Closeout Work Data Capture

Optimized Work Package



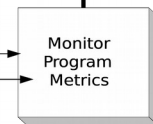
Projected OP Plan
(Timing Location TEMPO)

Diagnostics and Risk Prediction
Continuous Material Condition Assessment

Ship / Shore MRMS



Strategy Update



Success Story: LCS CBM+ Data Utilization



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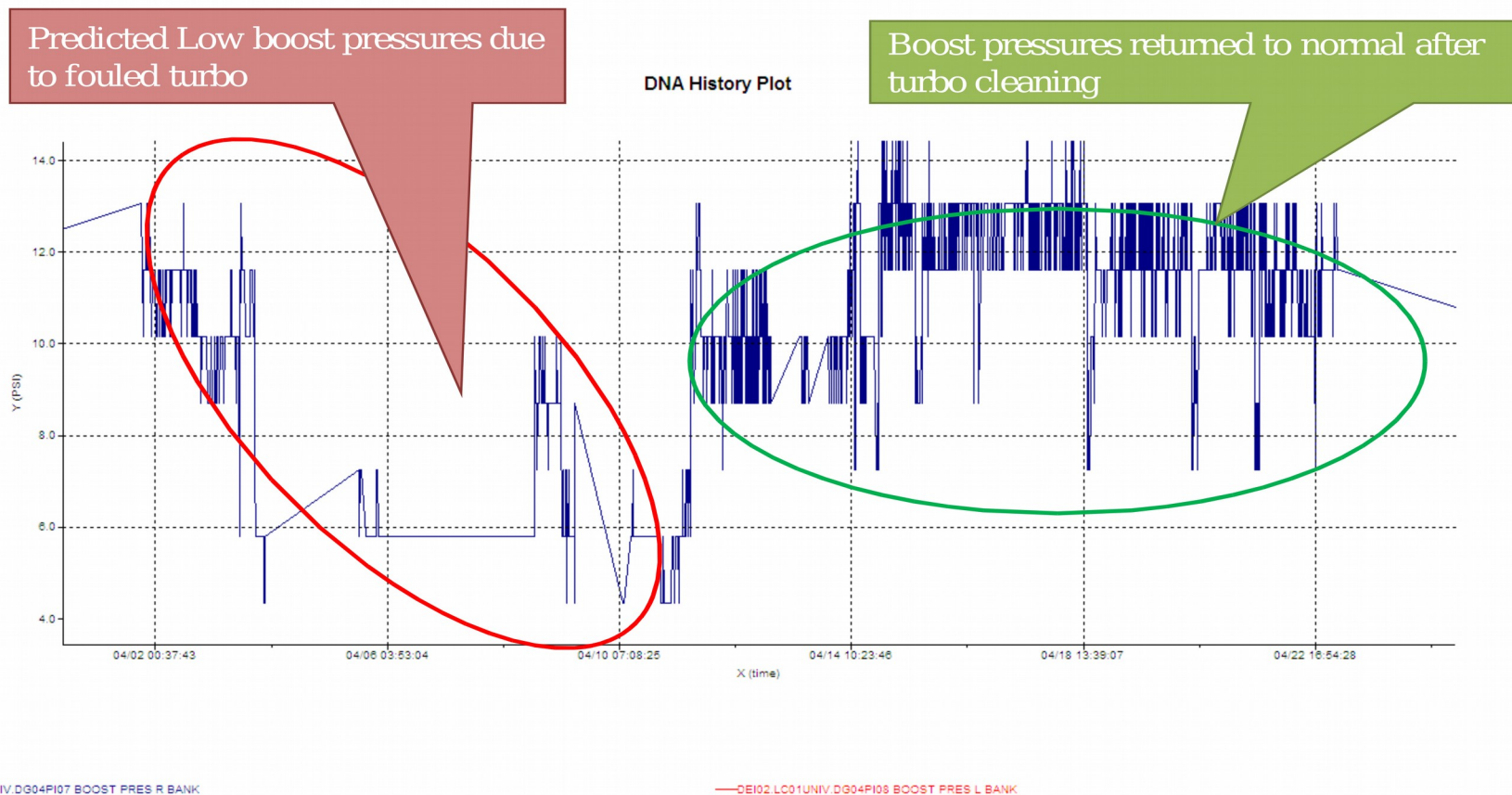
- All available system data (6,700.00 channels) is acquired at 1Hz frequency and stored in the MRMS Data Historian
- Data quality and consistency has been satisfactory for machinery diagnostic and prognostic analysis
- Available data received 4 times daily from ship-board MRMS component is analyzed and a Machinery Reliability Report (MRR) is distributed to appropriate personnel, including applicable maintenance and operational advisories
- LCSRON, Contracted Maintenance Provider, and SWRMC personnel respond to the identified recommendations through the advanced planning process related to upcoming availabilities
- Several equipment anomalies were identified and recommendations provided to the crew and to the CMAV planning activity
 - #2 AC Plant Cooler Fouling
 - Port & Stbd MPDE Turbo fouling
 - All 4 SSDG turbo fouling
 - MPAC First Stage Valve problem

LCS1# 4 SSDG Turbo Fouling Identification



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LCS1 DG04 Fouled Turbo Identification



Predicted Low turbocharger boost pressure identified in end of March 2010, circled in **red**. Planning was initiated to perform cleaning during CMAV 10A2 scheduled upon arrival in San Diego. Turbocharger compressor cleaned in April CMAV resulting in acceptable boost pressure, circled in **green**.

• **What is a Maintenance Free Operating Period?**

- MFOP is an alternative fielding and support strategy that is focused on reducing to the point of elimination any open cabinet maintenance for software intensive systems. The enabling technology is gleaned from the commercial market that is driven to reduce cost and overhead functions associated with deploying large-scale and mission critical software. These software tools and hardware redundancy designs support requirements for systems that are self-checking, self-healing and self-reporting. Highly reliable hardware, robust software, automatic failover and connectivity to a shore distance support environment are all needed to enable MFOP.

• **What are the objectives of MFOPs?**

- Increase operational availability, reduce open cabinet at-sea maintenance, and free up warfighter resources to concentrate on tactical operations. Endorse a proactive cost-wise approach to fleet sustainment where future systems are designed with proactive support solutions.

Open Architecture (OA) and Maintenance Free Operating Periods (MFOP)



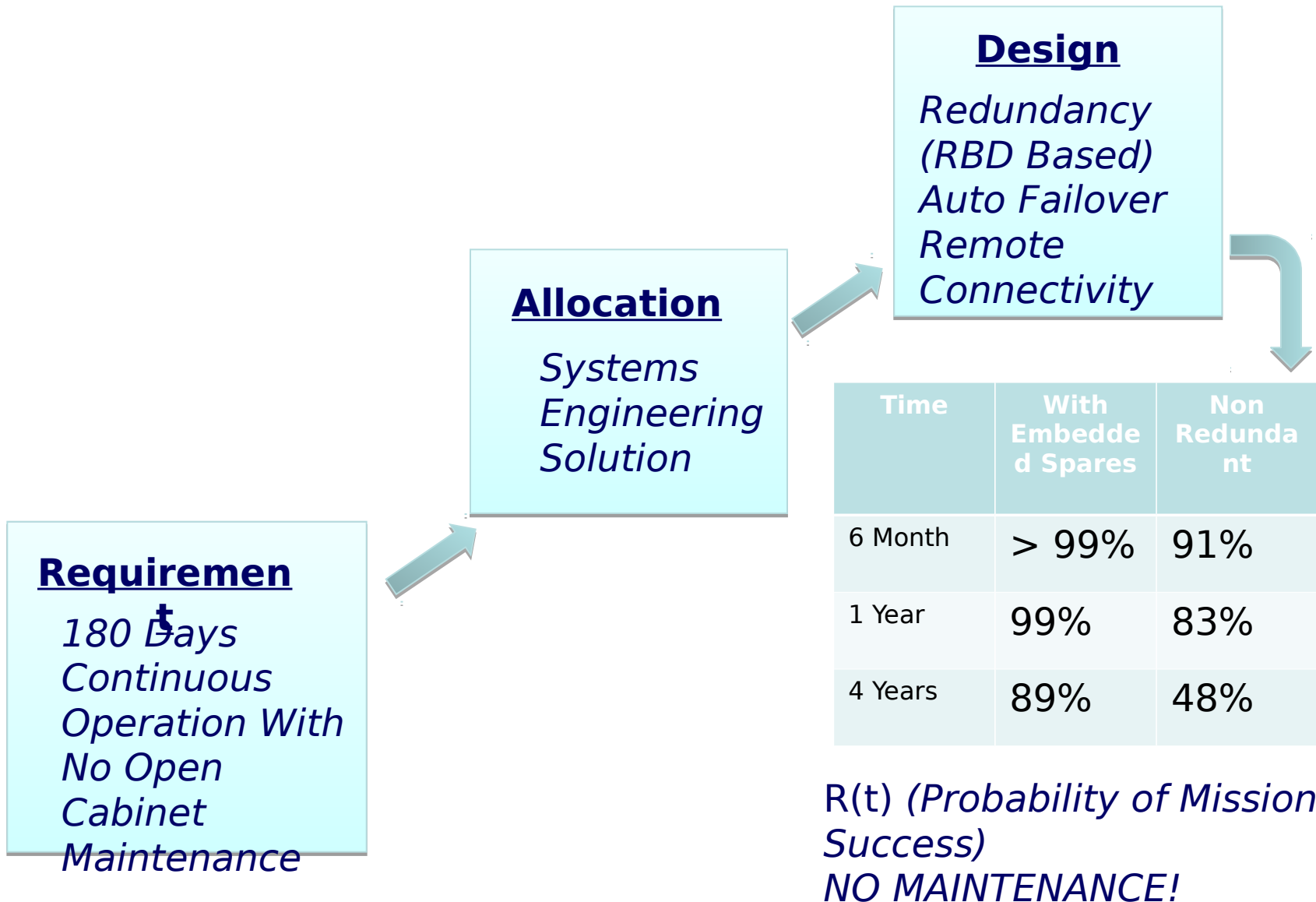
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- The Navy's success in building, maintaining and supporting a cost-effective future force and deterrent of 313 ships to meet its long-range war fighting requirements is directly linked to its success in implementing an innovative, capable, and cost effective Distance Support (DS) strategy.
- Open Architecture (OA) and derivatives of OA, such as Maintenance Free Operation Periods (MFOP), are considered key components.
- This OA/ MFOP demonstration incorporated software tools and hardware redundancy into a Commercial Off-the-Shelf (COTS) based OA system such that system self-checking, self-healing capabilities, and remote monitoring/ control virtually eliminated at-sea open cabinet maintenance.
- This is a common OA/MFOP concept application that is shared between Submarine and Surface Ship systems, which optimizes the OA investment by increasing operational availability and reducing open cabinet at-sea maintenance.

OA/MFOP Proof Of Concept Extensible Solution for MF Mission



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OA/MFOP Surface Ship Demonstration



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Six Month Deployment On USS IWO JIMA (7/10 to 1/11)



OA/MFOP Aboard USS IWO
JIMA LHD 7

System Ao >

99.7%

• **The Demonstration:**

- **Built A Fault Tolerant System**
 - Embedded Spares
 - Automated Failover
- **Remote Connectivity:**
 - System Admin Over SIPRNet
 - ROHMS Auto Data Collection
- **Collected System Behavior Data**
 - Lessons Learned
- **Met All MFOP Objectives**

**“Well Done Is
Better Than Well
Said”**

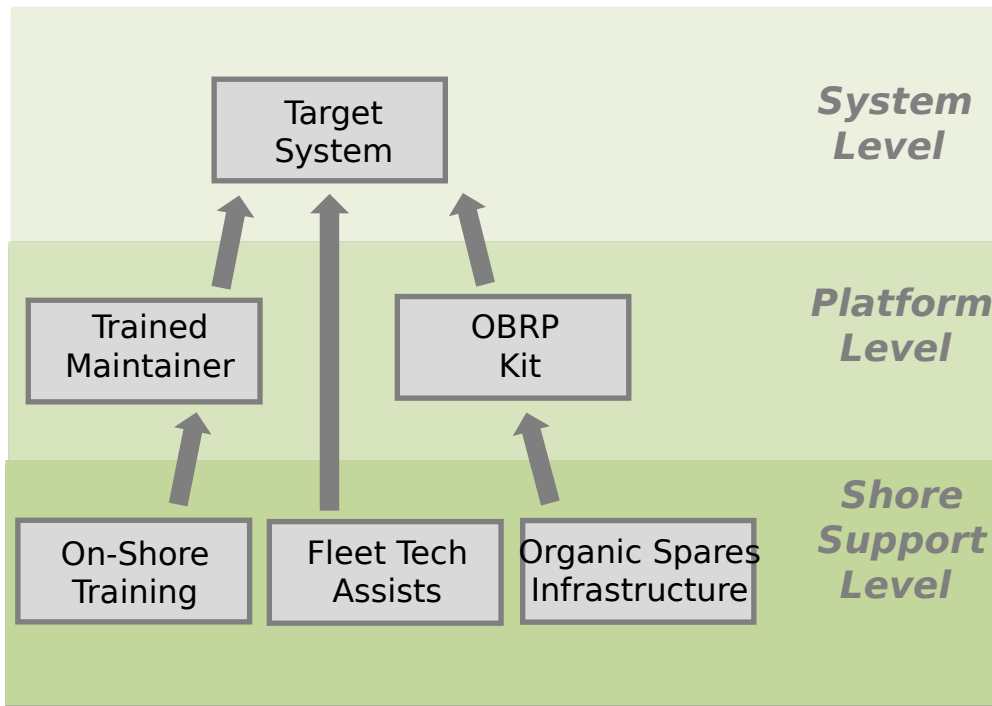


OA/MFOP In the Context Of Total Ownership Cost

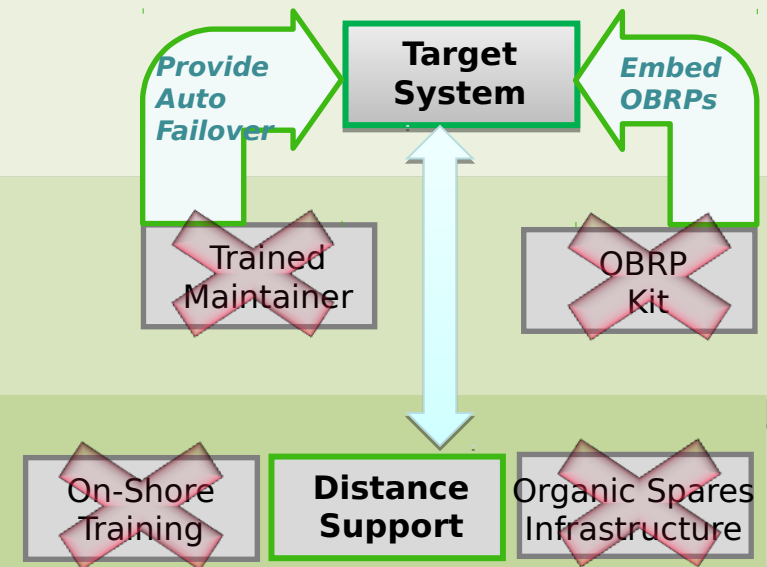


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Traditional System



MFOP Enabled System



Shipboard ILS is Eliminated in Favor of “Better-Cheaper-Faster” Distance Support

- CBM and MFOP can be processes that operate entirely within Navy organizations
- They can also operate with OEM/Vendor involvement, commitment and/or leadership.



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Questions?



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Back Up

- OPNAVINST 4790.16A of 2007
 - Supported by DoDI 4151.22, December 2, 2007
 - Supported by the Condition Based Maintenance Plus DoD Guidebook, 2008
 - Supported by DoD Memorandum of March 2007- Life Cycle Support Outcome Metrics for Weapon Systems
- SWE CBM Top Level Requirement published November 2008